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On the body-mind nexus in chronic musculoskeletal pain: A scoping review

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Significance: This scoping review identifies trends/gaps in current research on the relationship between body awareness/body image/body schema and pain-related psychological processes/outcomes in adults with musculoskeletal pain. Overall, findings suggest that better bodily experiences are associated to lower fear-avoidance beliefs, better self-regulation strategies and better chronic pain adjustment, being important targets in pain management interventions. Nonetheless, the results also emphasize the need to further investigate the causal relationships and other outcomes related to psychological resilience, as well as to develop gold standard treatments focused on bodily experience.

Abstract

Background and Objective: Bodily experience disturbances are frequent among chronic musculoskeletal pain patients and associated with important pain-related psychosocial outcomes (e.g., disability, quality of life). However, the relationship between bodily experience and the psychological dimensions of chronic pain (e.g., affective, cognitive) has only recently garnered attention. This scoping review aimed to identify trends and gaps in research on the nexus between body awareness, body image, and body schema, and psychological processes/outcomes in adults with chronic musculoskeletal pain to inform future directions for research and practice.

Databases and Data Treatment: This study was guided by Arksey and O'Malley's guidelines and PRISMA-ScR recommendations. Keywords related to body awareness/body image/body schema and pain were searched on PsycInfo and PubMed from database inception until February 16, 2021; 2045 articles were screened, and 41 met the inclusion criteria (i.e., primary quantitative studies investigating body awareness/body image/body schema in relation to pain-related psychological outcomes/processes in chronic musculoskeletal pain).

Results: The referred bodily experience constructs have been inconsistently defined. Body awareness was the most investigated construct, with consistent operationalization strategies. The links between body schema/body image and pain-related psychological processes/outcomes are still under-investigated. Most studies examined the role of bodily experience as a correlate/predictor of psychological outcomes/processes; overall, a better relationship with one's own body was associated with better pain-related psychological outcomes/processes.

Conclusions: Our findings emphasize the relevance of further investigating body-mind relations in musculoskeletal pain and the development of therapies designed to improve the

bodily experience within multidisciplinary treatment programs. Suggestions for future research are discussed.

Keywords: Chronic musculoskeletal pain, body schema, body image, body awareness, pain-related psychological outcomes, scoping review

1. Introduction

Chronic musculoskeletal pain has a remarkable worldwide prevalence (Cimmino and Cutolo, 2011), constituting a leading cause of global disability (Global Burden of Disease, 2017). The experience of one's own body (i.e., bodily experience) brings a significant contribution to understanding the body-mind interactions shaping chronic pain (Riva, 2018). Bodily experience is based on perceptual information from bodily senses and influenced by internal body information, which is reappraised through internal body representations (Riva, 2018). Although body-mind dualism has pervaded pain research, the links between physical senses and psychological processes have garnered recent attention (Eccleston, 2016). Contemporary embodiment theories (Barsalou, 2008; Clark, 2008) emphasize the central role of the body and sensorimotor experience in understanding psychological processes and mental disorders (Zatti & Zarbo, 2015). Pain-related psychological processes are significant determinants of musculoskeletal pain chronification and adaptation (Linton and Shaw, 2011; Vásquez and Araya-Quintanilla, 2019). Thus, understanding their relationship with bodily experiences may bear important implications for developing novel multimodal pain management interventions. Depending on the field of study, bodily experiences may refer to a sense of ownership (Giummarra et al., 2008), body representations (de Vignemont, 2018; Longo, 2016), or the awareness of bodily sensations (Mehling et al., 2009). Given the broad scope of such a complex field, this study specifically addressed aspects of bodily experiences that have been the focus of many body-oriented interventions with chronic pain patients (Lee et al., 2014 Morone and Greco, 2007), namely: body awareness (i.e., individuals' ability to be aware of own bodily states/processes/actions; Mehling et al., 2009) and body representations (Dijkerman and de Haan, 2007, Paillard, 1999), including body schema (i.e., an unconscious action-oriented sensorimotor body representation) and body image (i.e., a conscious

perceptive/cognitive/affective body representation). Henceforth the term bodily experiences will broadly refer to these constructs.

Persistent pain often comes along with changes in bodily experiences. Previous literature reviews (Di Lernia et al., 2016; Ravat et al., 2019; Tsay et al., 2015; Valenzuela-Moguillansky, 2012; Viceconti et al., 2020) reported that, compared to healthy participants, individuals with different chronic pain diagnoses presented body image and body schema disruptions and poorer body awareness, namely, lower ability to sense/interpret information on body posture (proprioception) and internal body states (interoception). Furthermore, disruptions on the perceptive dimension of body image were associated with longer, more severe, and incapacitating chronic musculoskeletal pain (Viceconti et al., 2020).

Although these reviews stress the fundamental role of bodily experiences in chronic pain, none focuses on the nexus between the body and pain-related psychological processes/outcomes. Yet, recent studies suggest that worse bodily experiences may be associated with psychological risk factors for musculoskeletal pain chronification, such as higher pain catastrophizing, fear-avoidance beliefs, and distress (Wand et al., 2016). Likewise, some therapies aimed at improving bodily experience decreased psychological distress (Bravo et al., 2019). These findings suggest that research should go beyond the mere description of pain-related bodily experience disturbances and further examine their relationship with the psychological dimensions of pain experiences.

This still undiscovered research field motivated this scoping review that investigates how the bodily experience of adults with chronic musculoskeletal pain has been studied in its association with pain-related psychological outcomes/processes. The specific research questions guiding this review were: a) which bodily experience constructs/dimensions have been mainly investigated? b) how have bodily experience constructs been operationalized?

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and c) which associations have been found between bodily experience and pain-related psychological processes/outcomes?

2. Methods

The methodological framework used to conduct this scoping review was guided by the recommendations proposed by Arksey and O'Malley (2005), further refined by Levac and colleagues (2010), and the PRISMA-ScR reporting guidelines for scoping reviews (Tricco et al., 2018). The review process entailed four main phases: a) identifying relevant studies, b) selecting studies for inclusion, c) charting the data and, d) collating/summarizing the information (see Figure 1). To this end, we developed a protocol (available upon request to the authors), which was strictly followed with minor deviations.

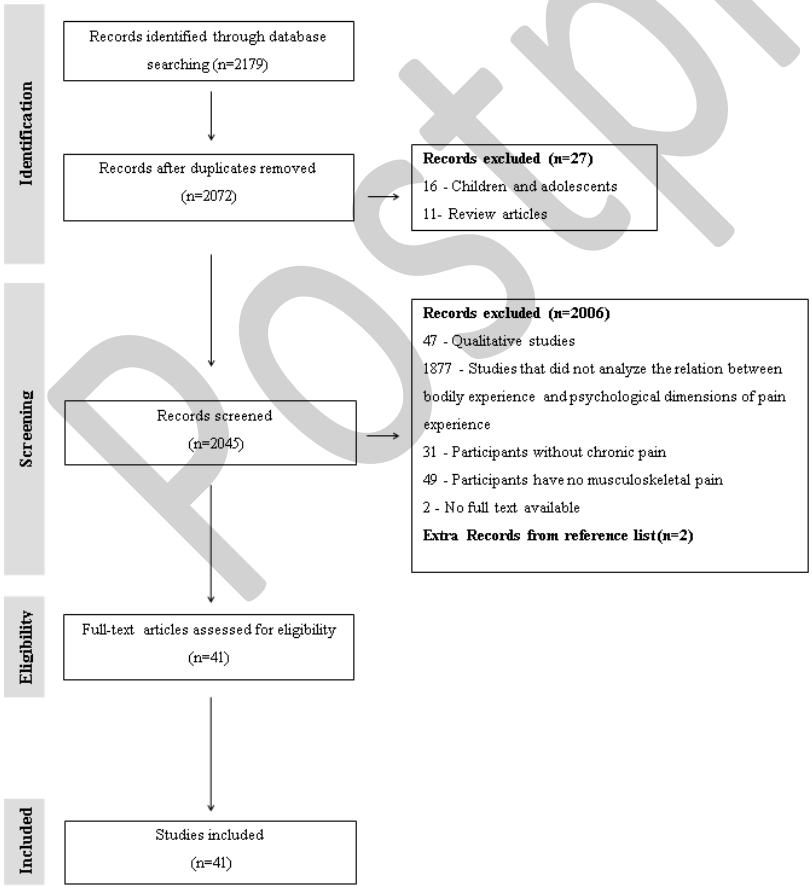

Figure 1. PRISMA-ScR flow chart showing identification and study selection (Tricco et al., 2018)

2.1. Identifying relevant studies

The search was conducted in psychological (PsycInfo) and biomedical (PubMed) databases to obtain a broad set of relevant articles. Drawing upon the PPC framework (Peters et al., 2020), the main elements in our research questions were: 1) Population: male and female adults (over 18 years old) with chronic musculoskeletal pain; 2) Concept: primary studies conceptualizing and measuring of bodily experience (body awareness, body image, and body schema) and its association with pain-related psychological outcomes/processes and 3) Context: studies conducted in any part of the world, both in clinical and laboratory settings. Based on these PCC elements, our constructs of interest, and how they are described in the literature (e.g., Valenzuela-Moguillansky, 2012; Tsay et al., 2015), the first author conducted a preliminary database search that was subsequently peer-reviewed by the second and third authors. Such preliminary search allowed fine-tuning the list of search terms to cover the field of interest. The final search (Appendix 1) was performed using the following keyword combination in each database: "Pain AND (Body schema OR Body image OR Body awareness OR Body consciousness OR Body perception OR Body distortion OR Interoception OR Interoceptive awareness OR Proprioception OR Proprioceptive awareness OR Embodiment)". In PubMed, the keywords were searched as "mesh terms" and in PsycInfo as "subjects". We have also included the filters "Humans", "English/French/ Portuguese/Catalan/Spanish languages", "Adults (+ 18 years old)" and excluded "review articles" and "dissertations/books/book chapters". The search was conducted from database inception until February 16, 2021.

2.2. Selecting studies for inclusion

The initial search retrieved 2179 articles, and after duplicates were removed, 2072 were retained. In line with the previous PCC elements, a set of inclusion/exclusion criteria guided our study selection for inclusion. Therefore, articles including samples of children and

adolescents (n=16) and review articles (n=11) were subsequently excluded. After this process, 2045 articles were retained for screening. Considering that previous reviews had already addressed the relation between bodily experience and pain disability or symptoms severity, we focused on the relationship between bodily experience and psychological factors, defined as intra-individual processes/outcomes of emotional, cognitive, or motivational nature. Papers were included if they consisted of primary quantitative research in adult samples and examined at least one bodily experience construct related to one psychological dimension of pain experiences. Studies that included psychosocial measures (e.g., pain-related disability, quality of life), but did not present findings specifically related to psychological processes or outcomes, were not included. We considered papers evaluating body-oriented therapies' efficacy - defined as interventions targeting the experience of the body with the potential to improve it - based on the exercises described, even when the authors did not mention the body as the main target. As there is little consensus in bodily experience terminology (Ceunen et al., 2016; de Vignemont, 2010), we agreed on a detailed concept definition, which guided our review and data extraction:

1. Body Schema - A non-conscious, coherent, and holistic representation of the body, in permanent interaction with the environment and constructed on an action-oriented sensorimotor basis that operates without the need of perceptive monitoring (de Vignemont, 2010; Gallagher, 2001).

2. Body Image - A multidimensional and conscious psychological experience of how individuals relate to their own bodies. It includes a perceptual dimension (accuracy in detection/estimation/identification of one's own body, regarding size and shape) and an attitudinal dimension (cognitions/feelings/behaviors towards one's own body) (Cash, 2012).

3. Body Awareness - The capacity of an individual to be aware of bodily states/processes/actions, including the perception of specific physical sensations, as well as

complex syndromes (Mehling et al., 2009). Since body awareness is a broad concept, whenever possible, we distinguished between two specific facets (Price and Mehling, 2016):

3.1 Interoceptive awareness - Sensing/interpreting/integrating information about the state of inner body systems. It includes the following features accessible to conscious self-report (Khalsa et al., 2018): attention (observing internal body sensations); detection (detecting presence/absence of a stimulus); magnitude (perceived intensity of internal bodily events); discrimination (localizing sensation within a specific channel or organ system, differentiating it from other sensations); accuracy (monitoring changes inside the body); insight (a metacognitive measure of subjective experience/performance); and sensibility (self-perceived tendency to focus on internal body sensations).

3.2 Proprioceptive awareness - Refers to the sense that enables the perception of the location, movement, and action of the body parts, comprising the perception of joint position and movement, muscle strength, and effort sensations, based on information from muscle, skin, joints, and from central signals related to motor output (Taylor, 2009).

Whenever identifying these facets of body awareness was not possible, we used the term "general body awareness". We classified the content of all the papers according to the presented definitions, even when they did not precisely correspond to the original terms used by the authors or when the constructs and respective dimensions were not explicitly mentioned.

At this stage, we scrutinized all the abstracts and excluded 2006 records, based on the following exclusion criteria: studies that (i) did not analyze the relationship between bodily experience and psychological outcomes/processes of pain (n= 1877); (ii) included participants without chronic pain (n=31); iii) included participants without musculoskeletal pain (n=49); iv) used qualitative methodologies (n=47), which would not allow us to uncover the specific associations between bodily experiences and pain-related psychological

processes/outcomes; v) did not have their full text available (n=2). Two additional articles were included after analyzing the reference lists of the consulted articles. Study selection was conducted by all team members who have different backgrounds (psychomotricity, pain psychology, and embodied social cognition). The first author screened all the abstracts. Three-quarters of these abstracts, including those that caused uncertainties, were subsequently peer-reviewed by the second and third authors separately. During the screening process, the team held regular meetings to assess the abstracts' selection and discuss those that caused uncertainty until consensus was reached. At the final stage, the second and third authors reviewed the full articles for inclusion separately. After the screening process, 41 articles were included in the review (see the complete list in Table S1).

2.3. Charting the data

The team developed a data-charting form (available upon request) to extract the data systematically. Data extraction was conducted by the first author. The second and third authors independently reviewed the extraction of the first ten studies to confirm if the extracted information was in line with the objectives. Subsequently, all data were double-checked by two independent researchers and reviewed by the second and third authors, with whom discrepancies were discussed and resolved by consensus.

2.4. Collating and summarizing the information

Results were organized in three tables addressing the different research questions. Studies were numerically identified with an ID, presented in the first column of Table S1. The overall characteristics of the studies are shown in Table 1, including the country of the authors' affiliations, study design, participants' sex and age, and pain location (Merskey and Bogduk, 1994). Data on the first and second questions (which of the bodily experience concepts and dimensions under examination have been studied and how have they been operationalized) are presented in Table 2, which includes constructs/dimensions and measures of bodily

experience. These constructs/dimensions were classified according to the previously established bodily experience terminology, and measures were categorized as self-report questionnaires, self-report rating scales, or task-based measures. Given its extension, the summary table of the main findings (Table S1) is presented as supplementary material (Supplemental Digital Content). The table is organized by each construct, and respective dimensions, and answers to the third question (which associations have been found between bodily experience and pain-related psychological processes/outcomes).

3. Results

3.1. Main characteristics of the studies

Table 1 presents an overview of the main characteristics of the studies. Overall, most studies were conducted in European Countries (43.9%), followed, in a much lower proportion, by studies conducted by authors/co-authors from more than one country (22.0%). More than half of the papers (65.9%) were relatively recent, with publication dates ranging from 2011 to 2020. All studies included adult samples, but none considered their developmental stages (e.g., early vs. late adulthood) in analyzing the results. Most papers included samples of both males and females (73.2%; ID#4-8, 10–17, 20, 21, 23, 26–28, 30–40), but only three analyzed sex-related differences (ID#27, 28, 31). The remaining only included women (ID#1-3, 18, 19, 22, 24, 25, 29, 41) or did not mention participants' sex (ID#9). Cervical, thoracic and lower back regions were the most studied regions (ID#4, 6–9, 11–15, 20, 21, 23, 26, 28, 29, 31–33, 35–38, 40), although generalized pain respecting syndromes such as fibromyalgia (ID#1-3, 6, 7, 18, 19, 22, 24, 25, 41), arthritis (ID#27, 28), chronic widespread pain (ID#16) or general muscle/joint disorders (ID#20) also generated considerable interest. Nearly half (53.7%) of the 41 reviewed studies presented a cross-sectional design. Experimental studies were also frequent, with randomized controlled trials accounting for 31.7% of the included

articles. Most of the experimental studies evaluated therapeutic programmes for chronic pain management, with exercises directed towards the body, focusing on body image (ID#25) and body awareness (ID#4, 6–8, 13, 15–23).

Study characteristics	N	Studies #ID
Authors' Country		
European Countries	18	2, 4, 6-8, 11, 13-16, 19-21, 26-28, 37, 40
Eastern Countries/Middle East	3	9, 24, 32
USA	5	5, 10, 17, 18, 31
International[1]	9	1, 3, 22, 23, 30, 33-36
Australia	3	12, 29, 38
Brazil	1	25
Canada	1	39
Chile	1	41
Year of publication		
Until 2000	5	10, 15, 19, 21, 31
2001-2010	9	5, 12, 13, 14, 16-18, 20, 26
2011-2020	27	1-4, 6-9, 11, 22-25, 27-30, 32-41
Participants' Sex		
Females only	10	1-3, 18, 19, 22, 24, 25, 29, 41
Mixed	30	4-8, 10-17, 20, 21, 23, 26-28, 30-40
N/R	1	9
Pain Regions		
Head, face, and mouth	4	10, 17, 21, 30
Cervical/thoracic/lower back regions	24	4, 6-9, 11-15, 20, 21, 23, 26, 28, 29, 31-33, 35-38, 40
Shoulder, upper and lower limbs	5	5, 20, 21, 34, 39
More than three major sites	15	1-3, 6, 7, 16, 18-20, 22, 24, 25, 27, 28, 41
Design		
Observational Studies		
Case-control	1	40
Cross-sectional	22	1-3, 5, 9, 11, 14, 24, 26-36, 38, 39, 41
Quasi-Experimental Studies	2	10, 12
Experimental Studies		
Uncontrolled trial/Single-arm clinical trial	2	8, 13
Controlled trials		
- Non-randomized	1	20
- Randomized (before-after trials/RCT's)	13	4, 6, 7, 15-19, 21-23, 25, 37

Table 1. General characteristics of the included studies: country, year, participants' sex, population diagnosis by regions, and study design. **Notes:** Numbers on column "Studies #ID" have the correspondent ID presented in Table S1; [a] International studies include authors from more than one country; the presented total number of studies (N) are not mutually exclusive.

3.2. Concepts and dimensions of bodily experiences

Overall, bodily experience constructs were only explicitly defined in about one-third of the analyzed articles (34.1%; (ID#1-4, 6, 23, 24, 26–28, 32, 35, 39, 41). In many articles, a bodily experience definition was entirely absent (ID#5, 7, 8, 10–22, 25, 29, 33, 34, 37, 40). As shown in Table 2, body awareness was the most frequently examined concept (61.0%; ID#1-23, 40, 41). Most of these studies focused on interoceptive awareness (36.0%; ID#1-7, 23, 41), mainly on sensibility (ID#2, 4–7, 23, 41), as compared to accuracy (ID#2, 3, 41), attention (ID#1) or insight (ID#2). The remaining studies focused on proprioceptive awareness (36.0%; ID#8-15, 40) and general body awareness (32.0%; ID#16-23).

Body image was the second most studied concept (31.7%; ID#24-36), but to a much lesser extent, and its perceptual dimension was the most investigated. Finally, body schema was only examined in five articles (12.2%; ID#37-41).

3.3. Assessment methods of bodily experiences

Body Awareness

As shown in Table 2, most studies on body interoceptive awareness focused on interoceptive sensibility, which due to its nature, was evaluated exclusively by self-report questionnaires. The Multidimensional Assessment of Interoceptive Awareness (MAIA; Mehling et al., 2012) was the most consistently used measure (ID#2, 4, 23, 41) and comprises eight dimensions: noticing; not-distracting; not-worrying; attention regulation, emotional awareness; self-regulation; body listening; and trusting. Other interoceptive features were assessed with task-based measures, such as the Heartbeat Detection Task-Schandry (Schandry, 1981) to measure accuracy (ID#2, 3, 41). This method evaluates the ability to detect the beating of one's heart by asking participants to silently count and then report the number of their own heartbeats over pre-determined time intervals presented in a random order, which is then compared to the actual number of heartbeats recorded via electrocardiogram. Proprioceptive awareness

was also mainly measured by task-based measures, of which position sense acuity tests were by far the most used. In these tasks, patients should reproduce or relocate a given position of the body part that is being assessed, such as cervical (ID#9, 11, 13, 40), trunk (ID#11), elbow (ID#12) or shoulder (ID#14). Of note, there is a recently developed self-report instrument to measure general body awareness, the Postural Awareness Scale (Cramer et al., 2018) (ID#23). Studies on general body awareness and proprioception also assessed individuals' perceptions of bodily states (e.g., awareness of tooth contact; ID#17; muscle tension; ID#10). Finally, only three studies used objective and subjective measures, thus capturing different facets of the same construct (ID#1, 2, 41).

Body Image

Body image was mainly assessed by self-report questionnaires. All papers on its attitudinal dimension used this methodology to evaluate individuals' satisfaction (ID#24) or feelings (positive, negative, or neutral) (ID#28) regarding various body parts or functions, as well as worries, evaluations, or behaviors around the body (ID#25-27). However, no specific measure was consistently used. Of the eight papers exploring the perceptual dimension of body image, six assessed individuals' perceptions of their own body forms and limits by using the Fremantle Back and knee Awareness Questionnaires (Nishigami et al., 2017; Wand et al., 2014; ID#29, 33–36) and the protocol of the Magnitude Estimation Scale (Skyt et al., 2015; ID#30). Only two studies on body image, both assessing its perceptual dimension, used task-based measures, namely body drawings (ID#32) and a perceived body space task (ID#31) (Fawcett, 1976).

Body Schema

All papers focusing on body schema used task-based measures almost entirely through the laterality judgment task (ID#37-40). In this task, pictures are shown in a random order to the participants, who are asked to quickly, accurately, and without moving, recognize body parts,

identify if they correspond to the left or the right side of the body, or if the person in the image is moving to the right or the left. The most common outcomes were accuracy (mean percentage of correct responses) and reaction times (in responding to each presented body part). Another used measure was the Body Scale Action Task (Guardia et al., 2010) (ID#41).

Constructs	**Dimensions**	**N**	**Studies #ID**
Body Awareness		25	
	Interoceptive awareness	9	
	- Sensibility	7	2, 4-7, 23, 41
	- Accuracy	3	2, 3, 41
	- Attention	1	1
	- Insight	1	2
	Proprioceptive awareness	9	8-15, 40
	General body awareness	8	16-23
Body Image		13	
	Attitudinal	5	24-28
	Perceptual	8	29-36
Body Schema	-	5	37-41
Measures		**N**	**Studies #ID**
Body awareness			
Interoceptive awareness			
Sensibility: Self-report questionnaires		7	2, 4-7, 23, 41
Accuracy: Task-based measures		3	2, 3, 41
Attention: Task-based measures		1	1
Insight: Task-based measures		1	2
Proprioceptive awareness			
Self-report rating scales		1	10
Task-based measures		7	8, 9, 11-14, 40
Without measures of bodily experience		1	15
General Body Awareness			
Self-report questionnaires		1	23
Self-report rating scales		1	17
Without measures of bodily experience		6	16, 18-22
Body Image			
Self-report questionnaires		10	24-29, 33-36
Self-report rating scales		1	30
Task-based measures		2	31, 32
Body Schema			
Task-based measures		5	37-41

Table 2. Constructs, dimensions, and measures of bodily experience.

3.4. The associations between the bodily experience and pain-related psychological processes/outcomes

The main results regarding the nexus between each examined bodily experience dimension and pain-related processes/outcomes are presented below. Overall, the pain-related psychological factors more frequently studied in relation with the bodily experiences included affective distress (ID#1–3, 5–8, 12, 17, 18, 21–25, 28–31, 33–36, 38, 39, 41), mainly anxiety and depression, catastrophizing (ID#1, 2, 5–7, 11, 18, 29, 30, 32–37), fear of movement (ID#9, 11, 13, 29, 33, 34, 36, 37) and self-efficacy (ID#6, 7, 13, 14, 19, 20). Only one study explored the relation of bodily experience with motivational outcomes, namely with the conservation of resources (ID#27).

3.4.1. Body awareness

Among the reviewed studies that addressed body awareness (n = 25), seven explored its associations with pain-related psychological factors (28.0%; ID#, 5, 9, 11, 12, 14, 40, 41). Fourteen studies assessed treatment effects of body awareness interventions on pain-related psychological outcomes. In these studies, body awareness was considered a predictor of psychological outcomes (56.0%; ID#4, 6–8, 13, 15–23). Finally, five studies focused on body awareness as an outcome of pain-related psychological processes (20.0%; (ID#1–3, 10, 14). Of the seven studies exploring the associations between body awareness and psychological factors, three of them revealed that higher body awareness was associated with better pain-related psychological processes/outcomes (ID#9, 14, 41), even though in some of them (ID#, 5, 12, 14, 40, 41) these associations were not statistically significant ($p > .05$), and one study showed the inverse association (ID#11). Higher interoceptive accuracy was associated with lower levels of depression and stress (ID#41). Likewise, higher proprioceptive acuity was associated with higher self-efficacy (ID#14). However, higher proprioceptive acuity was also associated with higher levels of catastrophizing (ID#11) and presented inconsistent

associations with kinesiophobia (#9, 11). Body awareness effects on depression and health-related quality of life were accounted for by pain-related catastrophizing and self-efficacy. Pain-related self-efficacy also mediated the effects of body awareness on pain-related disability (ID#7).

Overall, the findings from studies investigating the efficacy of body-oriented therapies to increase body awareness reported statistically significant effects ($p < .05$) on pain-related affective and cognitive outcomes. Regarding the affective outcomes, increased body awareness predicted better global mental health (ID#4, 6, 20), ability to enjoy life (ID#23) and distinguish, tolerate and express different emotions (ID#21), and lower levels of affective distress (ID#17, 21), depression (ID#6, 8, 18, 21), anxiety (ID#18, 21), somatization (ID#17, 21), obsessive-compulsive symptoms (ID#17, 21), interpersonal sensitivity (ID#21), anger (ID#21), fear of movement (ID#13), fear-avoidance beliefs (ID#15) and role limitations due to personal or emotional problems (ID#20). As for the cognitive dimensions, increased body awareness predicted better control over pain (ID#17), pain-related self-efficacy (ID#6, 19, 20), coping strategies (ID#18, 19), catastrophizing (ID#6, 18), and neuropsychological performance (ID#8, 18). One study showed that improvements in pain-related psychological processes (pain catastrophizing and self-efficacy) and outcomes (depression and global mental health) were only significant among patients who presented low body awareness at the time of the intervention (ID#7). However, only half of these studies measured body awareness to confirm the effectiveness of the intervention (ID#4, 6-8, 13, 17, 23). Indeed, only one study directly tested and confirmed the mediating role of interoceptive awareness on the positive effects of psychomotor therapy on depression (ID#7).

Finally, five studies examined psychological predictors of body awareness (ID#1-3, 10, 14), and two of them did not present significant results (ID#2, 3). Among fibromyalgia patients, increased pain-related affects and reactions (an index including levels of depression, pain,

catastrophizing, and somatosensory amplification) predicted lower interoceptive accuracy; higher emotional consciousness (an index including self-consciousness and the intensity of emotional reactions to typical life events) predicted higher interoceptive sensibility (ID#2). Moreover, groups of measures consisting of pain/catastrophizing/body image and somatic experience/interoceptive sensibility/self-consciousness partially accounted for the differences in interoceptive attention between fibromyalgia patients and healthy individuals (ID#1). Also, self-efficacy predicted proprioceptive acuity (ID#14) in patients with whiplash-associated disorders, and temporomandibular pain patients presented higher accuracy in internal states perceptions during a stress period than a non-stress period (ID#10).

Overall, these results indicate a consistent association between increased body awareness and better pain-related psychological dimensions. Most interventions focused on body awareness effectively improved psychological pain-related processes and outcomes, but stronger evidence on causality or temporal relations between these constructs is still needed.

3.4.2. Body Image

Of the thirteen studies addressing body image (ID#24-36), the majority examined cross-sectional associations between body image and psychological factors (ID#24, 26, 27, 29-36), one considered body image as a predictor (ID#25) of pain-related psychological outcomes and one considered body image as an outcome of post-traumatic stress (ID#28).

Although some studies did not report significant associations between body image and affective/cognitive outcomes (ID#24, 29-34, 36), most of them showed that improved body image was associated with better pain-related psychological dimensions. Concerning the perceptual dimension, lower body perception disturbance was associated with lower kinesiophobia in women with persistent lumbopelvic pain (ID#29), as well as in individuals with knee osteoarthritis (ID#34) and low back pain (ID#33). Likewise, individuals reporting better body perception presented lower affective distress (ID#33, 34, 35), catastrophizing

(ID#33, 34, 35, 36), and fear-avoidance beliefs about physical activity (ID#35). Regarding the attitudinal dimension, a better relationship with one's own body was related to higher perceived attractiveness and less suffering with worries around the body and physical, sexual discomfort in patients with ankylosing spondylitis (ID#26), and better mental health in fibromyalgia patients (ID#24). Moreover, more positive body-related attitudes and feelings were associated with patients' increased ability to achieve and maintain economic, political, spiritual, family, and vital resources (ID#27), being the latter association only significant among men. Additionally, belly dance sessions designed to improve the body image of women with fibromyalgia significantly improved their mental health and reduced their limitations due to emotional problems compared to a similar sample on a waiting list (ID#25). Finally, only one study explored the determinants of body image (attitudinal component), showing that men with more post-traumatic stress symptoms reported worse perceived upper body strength and lower fitness, which ultimately accounted for increased pain intensity (ID#28).

In a nutshell, although body image was scarcely investigated in its association with pain-related psychological outcomes, most of the existing evidence suggests that a better body image is associated with better psychological processes and outcomes.

3.4.3. Body schema

Only five included articles investigated the direct association between body schema and the psychological dimensions of pain experiences and presented inconsistent findings. Some studies did not show significant associations between body schema and psychological outcomes/processes such as affective distress (e.g., depression, anxiety, and post-traumatic stress; ID#38, 41) or fear-avoidance beliefs (ID#40). Other studies showed inconsistent results; better body schema performance was associated with lower levels of fear of

movement and catastrophizing (ID#37) in neck pain patients but also associated with higher affective distress (ID#39) among patients with wrist/hand pain.

In sum, the relation between the body schema and psychological dimensions of pain experiences has been under-investigated and presents inconsistent findings.

4. Discussion

This scoping review provides a comprehensive overview of how the bodily experience of adults with chronic musculoskeletal pain has been investigated regarding its conceptualization, assessment, and relationship to psychological processes/outcomes. Research trends/gaps are first discussed, which then inform suggestions for future avenues of research and practice.

4.1. Trends and gaps on bodily experience conceptualization and assessment.

Of the 2045 articles screened, only around 2% analyzed the relationship between bodily experiences and pain-related psychological dimensions, reflecting a body-mind split in current musculoskeletal pain research (Eccleston, 2016). Most papers focused on generalized and back pain, the most worldwide prevalent musculoskeletal disorders (Safiri et al., 2021), and were published in the last decade, indicating a recent and developing research field.

The first trend/gap reflects a striking lack of consensus on conceptualizing body awareness/schema/image, as only one-third of the articles included clear definitions. Aside from the few conceptualization/differentiation attempts (de Vignemont, 2010; Gallagher, 2001; Khalsa et al., 2018), inconsistencies in defining these body-related constructs persist. Albeit understandable, given the broad spectrum of disciplinary fields examining bodily experiences, this remains a serious barrier to the field's development. It hinders the proposal of integrated theoretical models, their operationalization, and application to uncover the

associations between bodily experiences and psychological processes/outcomes in shaping chronic musculoskeletal pain experiences.

Second, few studies assessed bodily experiences by triangulating methodologies. Consequently, results are likely to reflect a narrow perspective on (complex) bodily experiences, namely the link between their objective/subjective dimensions.

Third, body awareness was by far the most examined construct, likely because interoception and proprioception constitute solid topics in pain research (Ager et al., 2020; Di Lernia et al., 2016). Nonetheless, relationships between some interoceptive features (detection/magnitude/discrimination) and concurrent interoceptive processes (occurring on multiple physiological systems) with pain-related psychological outcomes/processes are still under-investigated, perhaps because only recently an interoception taxonomy was systematized (Khalsa et al., 2018).

Fourth, body image was the second most investigated concept, albeit to a less extent. Despite being a well-established construct in psychology (Cash and Smolak, 2011), in pain research, it has mainly been described from a sensorimotor/neurological perspective (Lotze and Moseley, 2007). Additionally, the diversity of its measures hampers firm conclusions on the reviewed body-mind relationships. Hence, despite solid evidence of body image disturbances in chronic pain patients (Sündermann et al., 2020) and body image relationships with mental health and illness adjustment (Swami et al., 2018; Beese et al., 2019), its relationship with psychological factors needs further investigation.

Fifth, body schema has attracted the least attention, possibly because it reflects an unconscious body representation more often studied from a neurological than a psychological perspective (Head and Holmes, 1911). Despite scarce, studies showed consistency in assessment strategies, enabling coherent interpretations of the findings. The body's postural and motor information is fundamental to emotional processing and higher mental functions

(Winkielman et al., 2015), so this gap in research hampers a complete understanding of body-mind relationships.

Finally, most studies were conducted with adults living in Western countries, without specifying their developmental stages, cultural or sex/gender differences. Diversity issues are critical to understanding pain and bodily experiences. Chronic pain prevalence is higher among women, older adults, and racial/ethnic minorities (Mills et al., 2019). Moreover, women demonstrate poorer body image than men; older adults present decreased body awareness; and there are different cultural/ethnic ideals of body image (Khalsa et al., 2009; Tiwari and Kumar, 2015). Further exploring diversity issues will promote findings' generalizations and tailoring interventions to the needs of specific patient subgroups.

4.2. Trends and gaps on the body-mind nexus research

First, most studies showed that chronic musculoskeletal patients with improved body image and body awareness reported better psychological outcomes (e.g., mental health, neuropsychological performance, affective distress). This goes along with previous evidence showing that better bodily experiences are associated with improved well-being in healthy populations (Swami et al., 2018) and better illness adjustment outcomes (Mehling et al., 2009), such as lower pain-related disability in chronic musculoskeletal pain patients (Viceconti et al., 2020). These findings contribute to the development of clinical interventions targeting body-mind relationships. However, due to the sparse and inconsistent evidence on body schema, its relationship with psychological outcomes is still unclear. Nonetheless, as body schema and body image shape each other (Pitron et al., 2018) and better body schema is associated with lower illness impact or disability (Valenzuela-Moguillansky, 2017), it is reasonable to expect that improved body schema is associated with better pain-related psychological outcomes.

Second, the reviewed findings suggest that better body awareness and (perceptual) body image are associated with protective cognitive (self-efficacy, control over pain) and affective processes (emotional consciousness, discriminate/tolerate emotions) underlying chronic pain adjustment (Linton and Shaw, 2011). In contrast, findings also show that poorer body awareness/image are associated with cognitive (catastrophizing, fear-avoidance beliefs) and affective processes (kinesiophobia) that predict pain persistence and poorer adjustment outcomes (Vásquez and Araya-Quintanilla, 2019; Vlaeyen and Linton, 2000). These findings are consistent with previous evidence showing the role of interoceptive/proprioceptive stimuli in pain-related fear conditioning (Vlaeyen and Linton, 2012; Meulders, 2020) and of body awareness shaping (mis)interpretations of bodily cues and associated pain-related thoughts/emotions/behaviors (Price and Mehling, 2016). Better bodily experiences are also likely to be associated with resilience-related psychological processes, such as emotion regulation, psychological flexibility, acceptance, or mindfulness, which are often the target of third-generation psychological therapies (Hayes and Hofmann, 2017). These associations are yet to be investigated.

Third, most studies uncovered the influence of bodily experience on psychological processes/outcomes, so the extent to which the latter promote/hinder bodily experiences is less known. Although some authors argued for the role of pain-related fear-avoidance in disrupting individuals' body schema and interoception (Valenzuela-Moguillansky et al., 2017), the extent to which pain-related psychological processes predict patients' bodily experiences remains to be tested. Moreover, body-mind temporal and causal relationships are under-investigated, as nearly half of the studies were cross-sectional, and many randomized clinical trials did not measure the body-related constructs targeted by the intervention.

Fourth, results confirmed therapies' effectiveness (mostly on body awareness) in improving psychological outcomes (e.g., depression, anxiety) and processes (e.g., catastrophizing, self-

efficacy, kinesiophobia). This goes in line with the literature showing that the ability to perceive and correctly interpret bodily states helps restructuring cognitive biases and buffering emotional reactivity, leading to more adaptive behavior (Price and Mehling, 2016). Therefore, improving the bodily experience can be an asset in psychological therapies; improved body image facilitates acceptance (Markey et al., 2020; Sakson-Obada et al., 2017), and body awareness facilitates emotional regulation (Ekerholt et al., 2014; Price and Hooven, 2018). However, like in previous reviews (Viceconti et al., 2020), this study did not find a gold standard treatment targeting bodily experience, and conclusions about the comparative effectiveness of therapies and their key elements are hindered by their diversity. Only one study considered subgroups based on individuals' level of body awareness, thus inclusion/exclusion criteria to attend body-oriented therapies or how to tailor interventions to individuals' idiosyncratic bodily experiences remains unclear. Considering the findings on the association between body image and pain-related psychological dimensions, it is reasonable to expect that, like in other clinical conditions (Sakson-Obada et al., 2017), interventions on body image may improve pain-related psychological outcomes. The extent to which pain-related psychological therapies may change patients' bodily experiences could be further investigated.

Also, no study focused on the effects of psychological interventions on bodily experiences. Given the extensive evidence on their effectiveness in improving body image in general (Tiwari and Kumar, 2015), this is a critical gap in pain research.

4.3. Limitations and future directions for research

This scoping review has some limitations worth mentioning. First, it focused on research conducted with adults with chronic musculoskeletal pain, thus preventing generalizations of conclusions to other populations such as children/adolescents and/or other chronic pain disorders. Second, considering the broad and complex field of bodily experience, only body

representations and awareness were explored, leaving out potentially important dimensions (e.g., body ownership). Third, despite being comprehensive and complimentary, only two databases were included in the review. Moreover, if we had followed the search strategy recently recommended by The Joana Briggs Institute (Peters et al., 2020), the range of our search terms could have been wider. Fourth, considering the characteristics of scoping reviews, no conclusions can be drawn regarding studies' quality, significance/magnitude of effects, or clinical recommendations.

Despite these limitations, to the best of our knowledge, this is the first review addressing research on the relationship between bodily experiences and psychological outcomes/processes in chronic (musculoskeletal) pain. The trends/gaps previously discussed inform avenues for future research and clinical practice. First, the development of a consensual taxonomy of body-related constructs is critical. Recent interdisciplinary expert collaborations have successfully reached a consensus regarding interoception (Khalsa et al., 2018). Similar efforts should be pursued for body representations (body schema/body image) and different levels of body awareness. Second, future studies should triangulate standardized/validated assessment methods tapping multiple facets of bodily experiences. Objective and self-report measures can complement each other, providing critical insights into pain-related bodily experiences. Third, body-mind relations warrant further research, particularly concerning body schema, body image, and interoceptive features beyond sensibility/accuracy. A recent cognitive-behavioral model on the bidirectional relationships between pain and body image (Sündermann et al., 2020) and an interoception conceptualization/taxonomy (Khalsa et al., 2018) can inform future research. Moreover, developing integrative theoretical models conceptualizing how the body-mind nexus shapes chronic pain is important to developing more effective interdisciplinary treatments. This is particularly relevant considering recent evidence suggesting that, overall, interdisciplinary

(vs. unidisciplinary) approaches are more effective in improving pain-related outcomes (Vowles et al., 2020). Like Valenzuela-Moguillansky and colleagues (2017) proposed the inclusion of bodily experiences (body schema and interoception) in the fear-avoidance model, further conceptual integration efforts are warranted.

Fourth, studies should address diversity issues by considering the role of life developmental stages, sex/gender, and cultural/ethnic factors on the body-mind nexus. Fifth, the role of bodily experience on psychological processes should be further examined, particularly resilience factors such as emotional regulation, acceptance, and psychological flexibility. Sixth, high-quality prospective studies are needed to elucidate the causality of body-mind relationships and their role in pain chronification. Moreover, randomized control trials testing the efficacy of interventions on bodily experiences should include valid assessments of the latter to clarify the potential benefits achieved throughout the body. Seventh, standardized intervention protocols to improve body awareness should be developed, for both psychological and body-oriented therapies, identifying specific targets and inclusion criteria. More interventions aiming at body image/schema could also be designed and tested. Finally, bodily experience should be routinely assessed in clinical settings within an interdisciplinary approach, allowing respective disruptions to be properly identified/treated. In sum, examining body-mind relations in chronic musculoskeletal pain is an emerging and promising field that may contribute to developing more effective multidisciplinary treatment programs.

Appendix

Further description of search strategy and results is available in Supplemental Digital Content.

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Author Contributions

All authors have made substantive intellectual contributions to the study concept and design, analyses and interpretation of data, as well as in writing and revising the paper, approving the final version to be published. IO conducted the database search, articles screening, and data extraction. These procedures were peer-reviewed by MG and SB, who also discussed all abstracts that caused uncertainty at the screening stage; SB coordinated/supervised all the work.

Conflicts of interest

The authors claim that there are no conflicts of interest.

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